A Small Sample!

Ames Research Center Activities in AI and Data Science

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The Data Sciences Group at NASA Ames

Machine Learning and Data Mining Research and Development (R&D) for application to NASA problems (Aeronautics, Earth Science, Space Exploration, Space Science)

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Funding Sources

- NASA Aeronautics Research Mission Directorate- SWS, CAS
- NASA Engineering and Safety Center (NESC)
- Human Research Program (HRP)
- Center Innovation Fund (CIF)
- JPL Advanced Multi-Mission Operations System (AMMOS)

Team Members are NASA Employees, Contractors, and Students.

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Example Problems / Aeronautics:

- Anomaly Detection
- Precursor Identification
- text mining (classification, topic identification) of safety reports
- relating pilot fatigue to aircraft performance
- identifying patterns in RNAV waypoint compliance
- Surrogate modeling for helicopter noise

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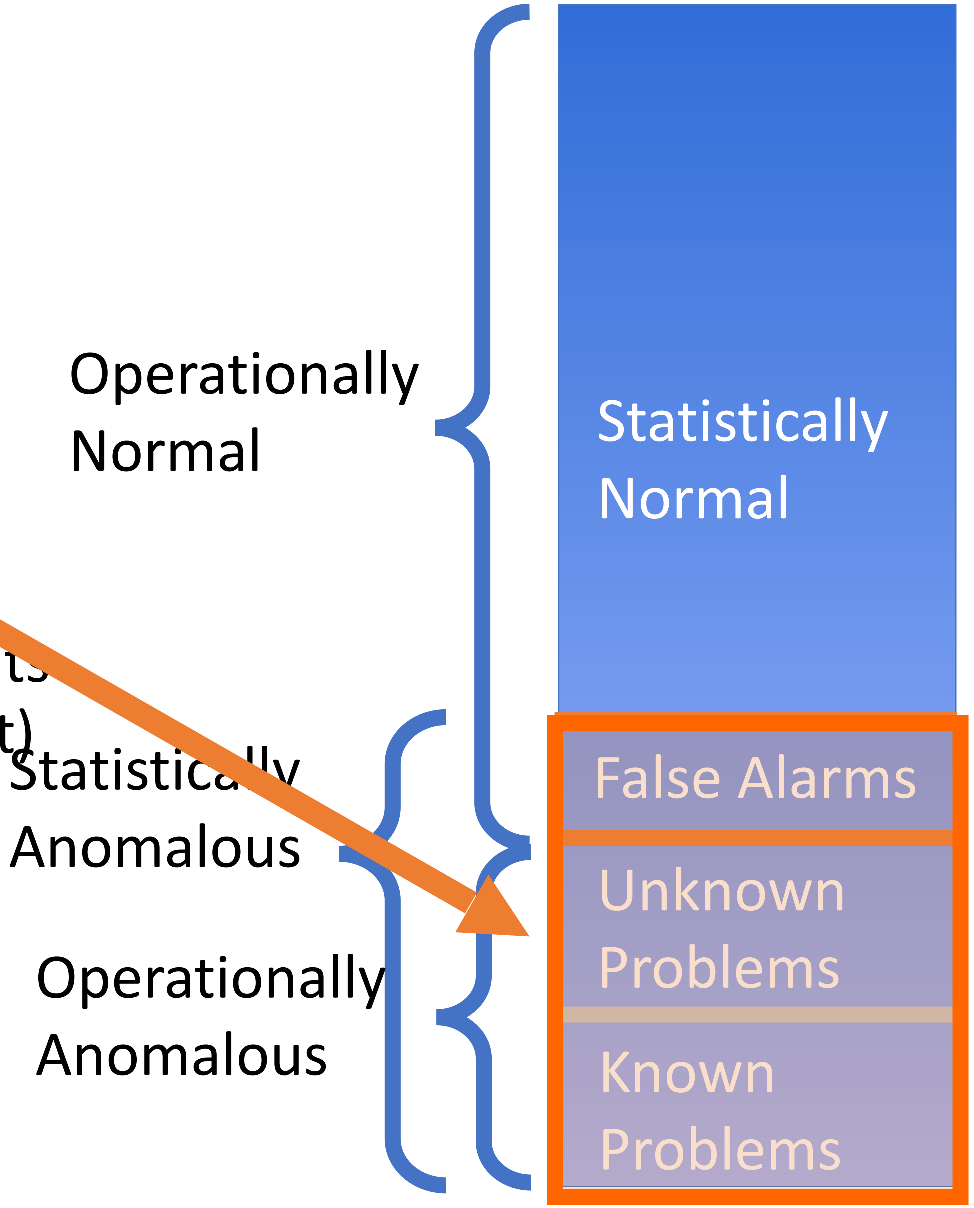
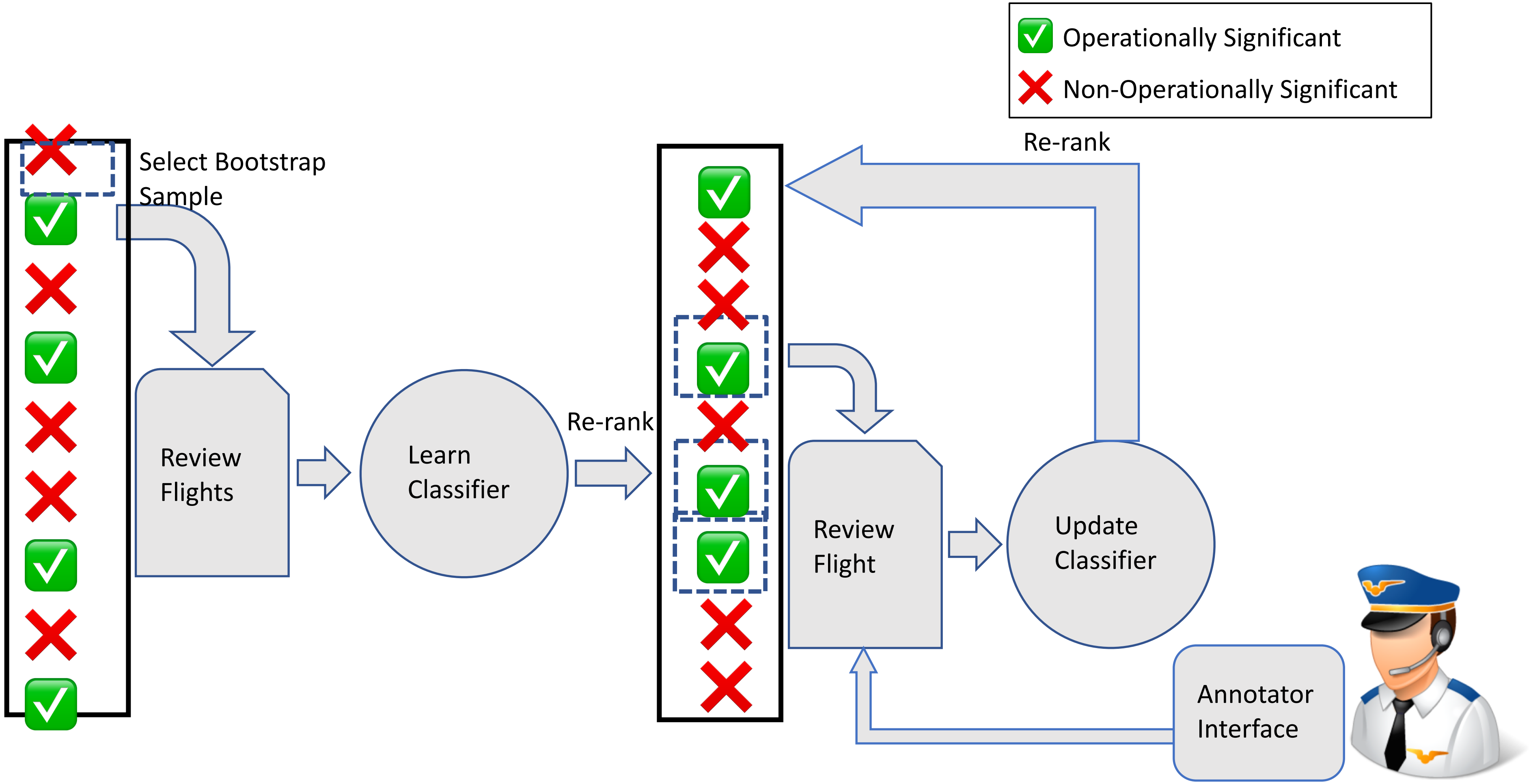
Data-Driven Methods

- DISCOVER anomalies by
  - learning statistical properties of the data
  - finding which data points do not fit (e.g., far away, low probability)
- Complementary to existing methods
  - Lower false negative (missed detection) rate
  - Higher false positive rate (identified points/flights unusual, but not always operationally significant)
- Data-driven methods -> insights -> modification of exceedance detection



Active Learning Approach



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Example Problems / Aeronautics:

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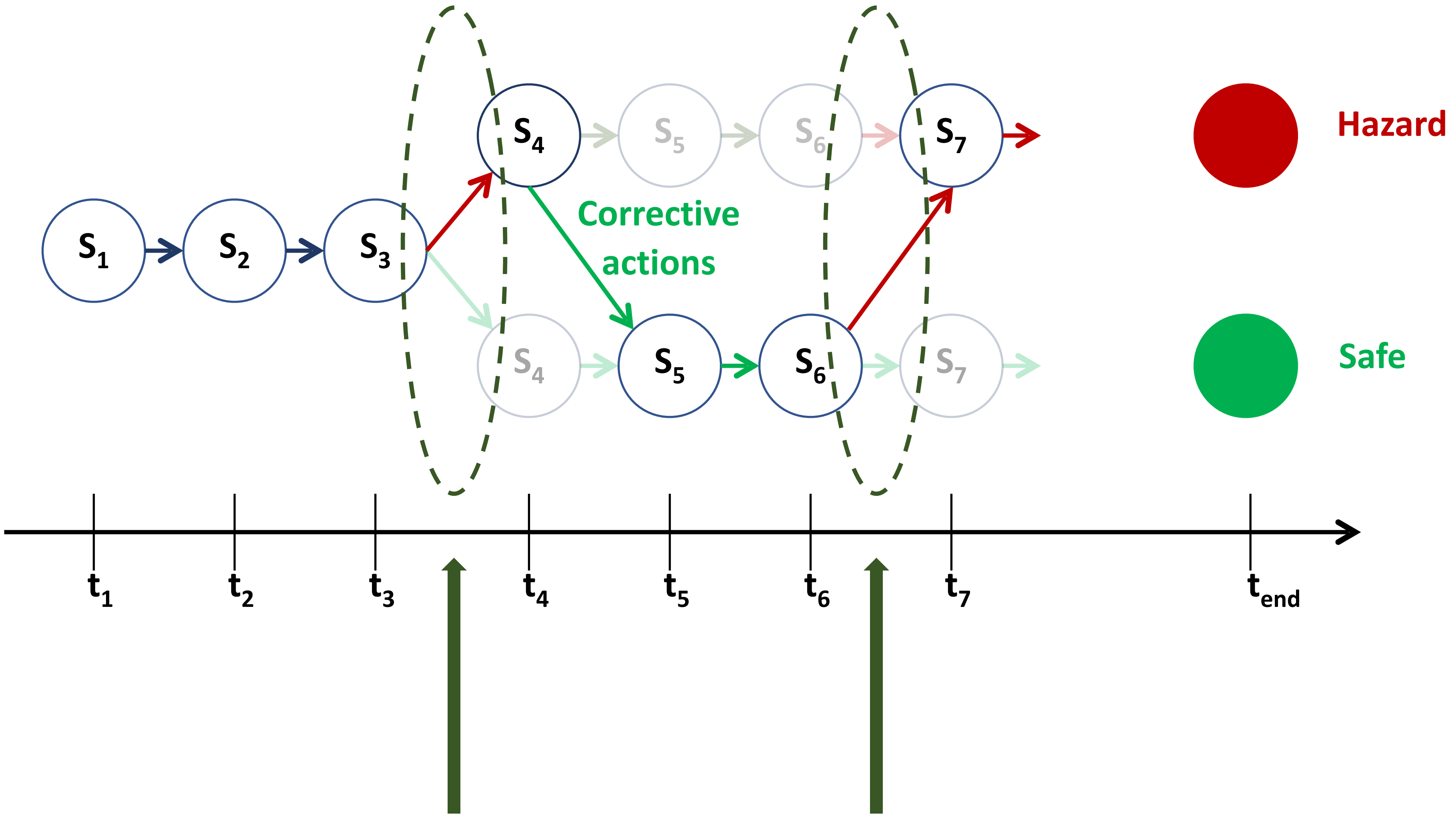
Precursors



S1
S2
S3
S4
S5
S6
S7
S4
S5
S6
S7
Corrective actions
Hazard
Safe
t1
t2
t3
t4
t5
t6
t7
tend

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Example Problems / Earth Science

- Filling in missing measurements (e.g., ground-based pollution sensors) through relationships with other measurements (e.g., satellite remote sensing)
- anomaly detection
- graph mining to find teleconnections and changes in them
- learning relationships between vegetation and climate variables through symbolic regression

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Example Problems / Space

- Space Science: Kepler and TESS planet candidate identification
- Human Space Exploration
  - system health management (monitoring ISS using in-house Inductive Monitoring System)
  - vascular structure identification for astronaut health
  - machine learning within Advanced MultiMission Operations System (AMMOS)

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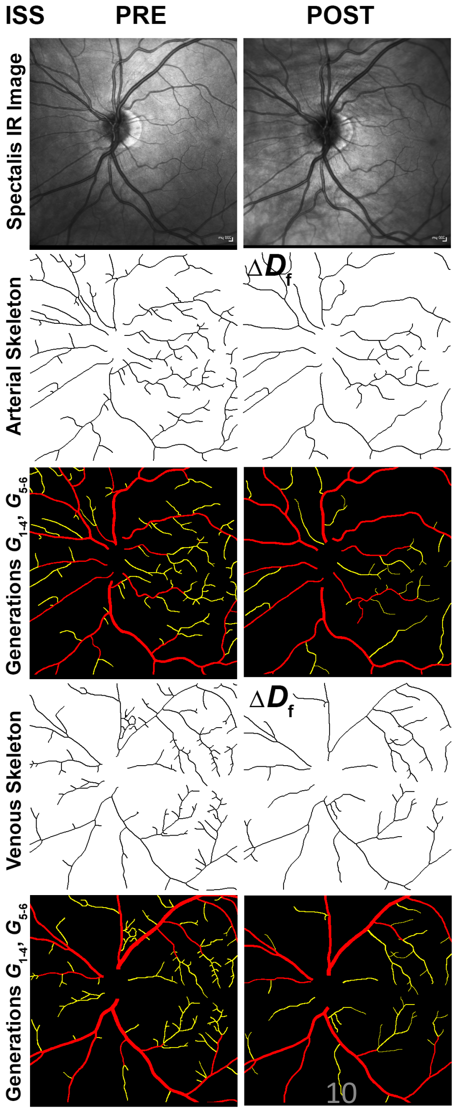
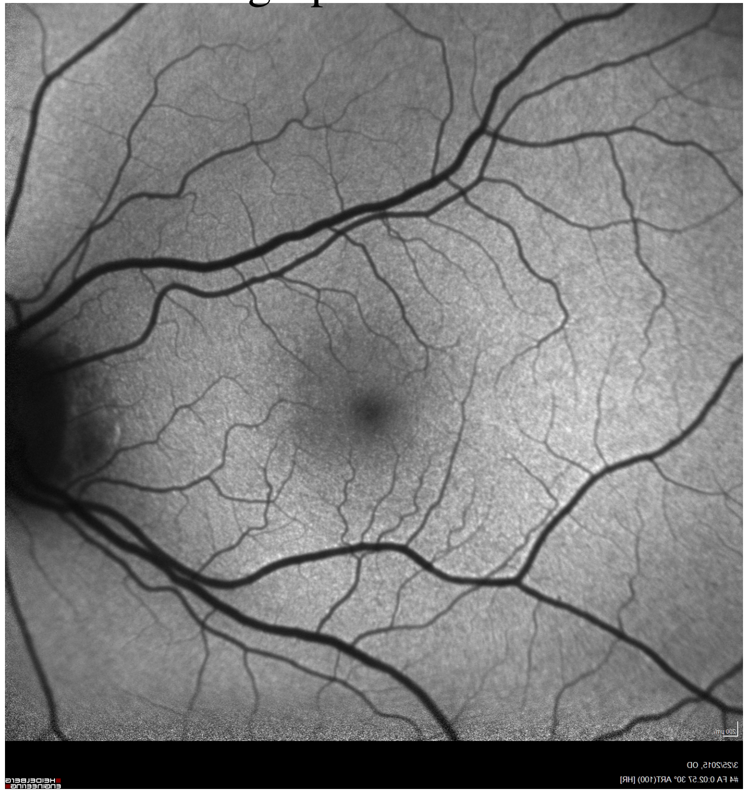
VESGEN (VESsel GENeration) Software

- Developed by Dr. Patricia Parsons and VESGEN lab in Glenn Research Center and later in NASA ARC
- Maps and quantifies vascular morphological characteristics
  - parameters such as diameter, length, branch points, density, and fractal dimension
- Applications
  - Progression of human diabetic retinopathy
  - Remodeling of plant leaf venation patterns in response to plant growth, genetic engineering, and other growth perturbation
  - Progressive Vascular Inflammation in Gastrointestinal Systems (GI): Important for Astronaut Risks in High Radiation Environments
  - Analysis of loss of vessel density in Spaceflight Associated Neuro-ocular Disorder (SANS) (Picture: VESGEN results for ISS Crew Member retina)



Objective

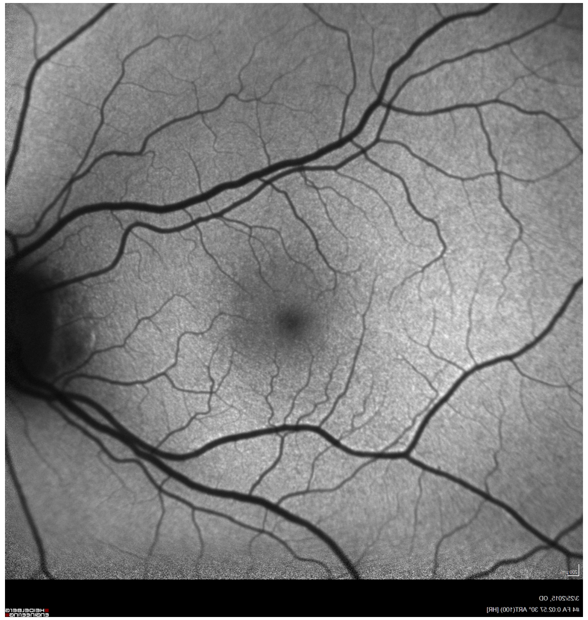
Heidelberg Spectralis IR mode

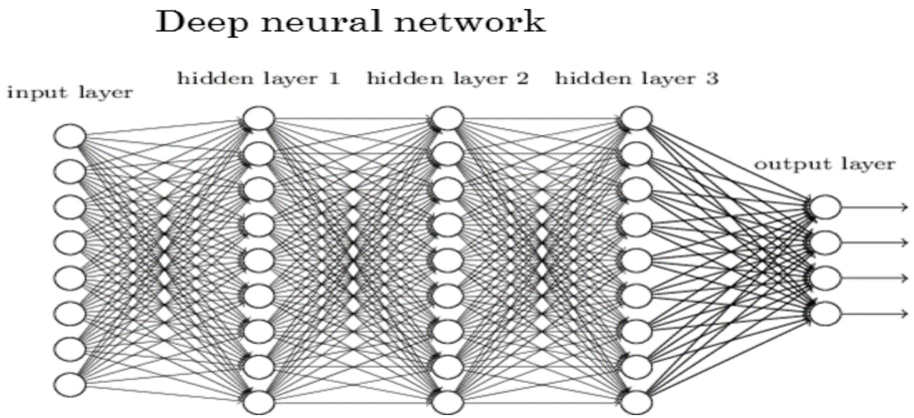


Binarization

- VESGEN requires binary (vascular systems vs. background) image as input
- Currently, manual binarization is being done before feeding the image to VESGEN for analysis
  - Very time consuming and inefficient (2-15 hours image preparation for VESGEN)
- We developed a more automated approach

Supervised Approach: Deep Learning

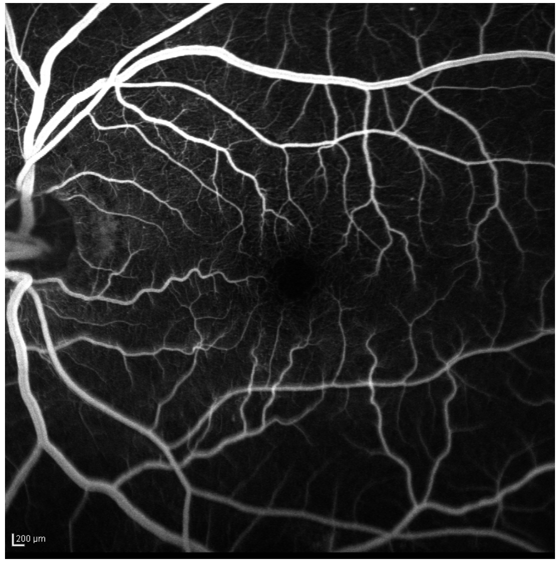




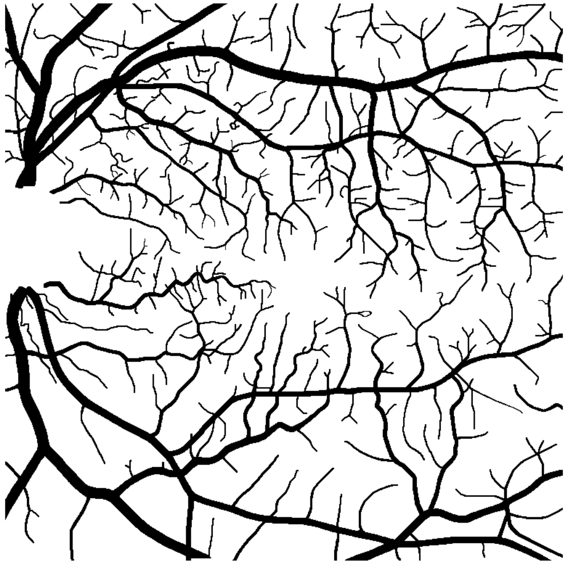
- Assumes existing manually binarized images are provided
- Common practice: whole non-binary image as input; whole binarized (segmented) image as output
  - Learns the mapping from original non-binary image to binary image
  - Such supervised learning models require thousands of images as input/output to learn the task
  - Lack of enough binarized images: 35 vascular images only
- Training time depends on total number of training examples, difficulty of the problem, size of network

Binarization result (NASA data set)

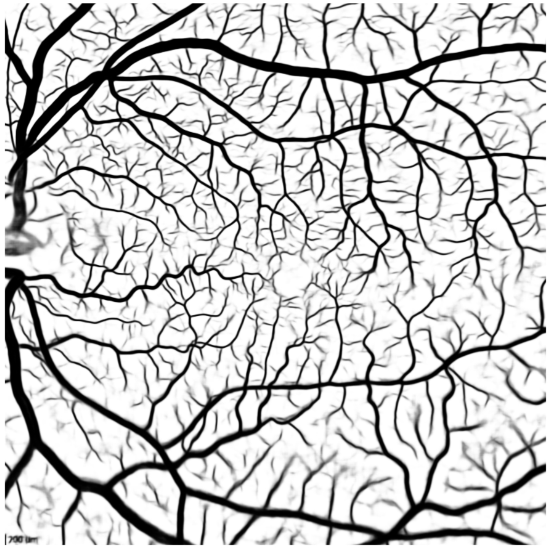
Per Patch	VESGEN
Accuracy (%)	94.61
Precision (%)	81.59
Sensitivity (%)	85.39
Specificity (%)	96.48
AUC	0.9768

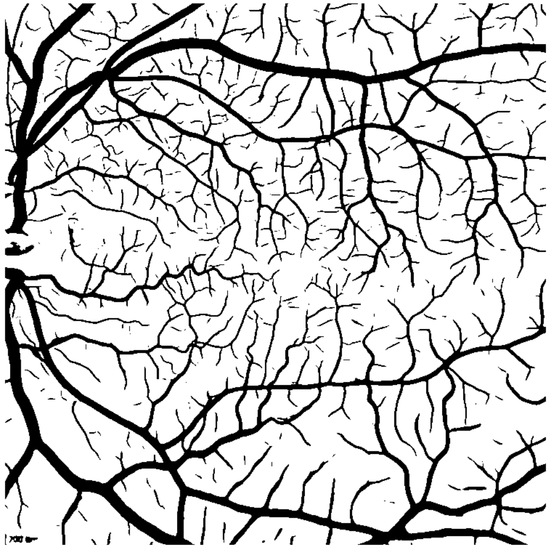


Ground truth

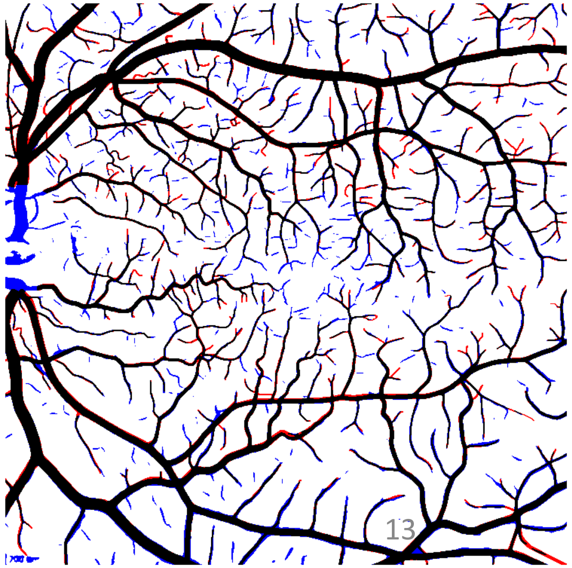


Output heatmap





False positives (blue)/negatives (red)



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